

A guide to replacing an Analogue FM repeater with a DV repeater.

This document is a guide for amateur radio clubs interested in replacing Analogue FM repeaters with D-Star, Yaesu Fusion, P25 or DMR-TRBO equivalents.

This document concentrates on the D-Star system.

D-Star is not exclusively ICOM as a lot of people incorrectly report.

Only the D-Star name is registered to ICOM.

At the time of writing ICOM is the only radio manufacturer with off the shelf equipment.

Analogue FM radios with 9600 packet ports can be used with an external GMSK modulator and Vocoder unit such as the DV Dongle or DV3000.

Many people I have spoken to on D-Star are using surplus Yaesu FT-8800, GE, Philips and Tait radios. Yaesu Fusion C4FM and Alinco DV are lesser known with minimal infrastructure at the time of writing.

The common DV versions used or available for amateur radio:

D-Star - Digital Smart Technologies for Amateur Radio. 6 kHz FM and HF Standard.

FreeDV – Narrow band 1.5 kHz DV standard for amateur radio.

P25 – Project 25 Phase 1 and Phase 2 (used primarily for commercial)

DMR – Digital Mobile Radio (used primarily for commercial)

NOTE: P25 Phase 2 and DMR use TDMA (Time Division Multiple Access) and are distance limited.

For ham radio DX distances more than 120kms via repeaters D-Star and P25 Phase 1 are the most reliable DV modes to use. P25 Phase 1 uses 12.5 kHz bandwidth compared to D-Star 6 kHz bandwidth.

D-Star is the only DX capable system with add on DIY devices such as DV Dongle, DVAP Hot spot, Raspberry Pi and Arduino interfaces. DVRPTR GMSK boards and MoenComm GMSK boards can be used to convert FM repeaters and radios into D-Star capable units.

Branch 63 D-Star experience:

The existing UHF analogue repeater “860” using RX 433.6 MHz and TX 438.6 MHz was simply swapped for an ICOM D-Star RP-4000 repeater. Valid reasons to retain the analogue 860 repeater were:

- 1) For maintenance purposes in case of RP-4000 failure.
- 2) To monitor and then fox hunt QRM sources from SRD’s (Short Range Devices) used on 433.05 MHz to 434.79 MHz.
- 3) If D-Star was not popular revert to the analogue FM repeater.

In order to find QRM on a DV system BER (Bit Error Rate) test equipment is required. Branch 63 found that using the analogue repeater allowed them to monitor for false triggering and hear the SRD’s in the back ground during two way contacts.

Previously CTCSS on 433.6 MHz was used to prevent false triggering.

While using DV on 860 occasional data loss is noticed (R2D2 effect) due to SRD type QRM.

At the time of writing it is not severe enough to warrant inverting the 860 repeater frequency pair. In time this could change.

- 4) If D-Star did not generate an increase in activity the analogue repeater could be put back into service. Branch 63 was not proven wrong with the largest growth in membership for many years resulting from the introduction of D-Star. “D-Star was here to stay” therefore item 3) above is no longer a consideration.

The hardware:

D-Star or DV installations should be treated as a NEW install.

Branch 63 found that although they had a rarely used analogue UHF repeater the swap over to the DV RP-4000 was not without difficulty.

The duplexer was out of tune, the antenna and coaxial cable was old.

The duplexer was then professionally adjusted with excellent performance results.

See this web site for details: http://z12vh.org.nz/assets/pdf/other/RP4000_Duplexer.pdf

A bonus of this type of duplexer is that other repeaters can share the duplexer antenna combination with appropriate use of circulators.

The antenna was found to be faulty and a water logged coax needed replacement.

The coax was replaced and a new SkyMast antenna installed.

This antenna meets the newest PIM (Passive Inter-Modulation) specifications and has a wind loading of 160 km/hr. i.e. built to last at Mt.Climie.

See this web site for details: http://www.z12vh.org.nz/pdf/other/Mt_Climie_S-M4_Repeater_Antenna.pdf

Also here: <http://www.z12vh.org.nz/pdf/other/S-M4.pdf>

PIM:

Passive inter-modulation (PIM) is a form of inter-modulation distortion that occurs in passive components such as antennas, cables, connectors, or duplexers with two or more high-power input signals. PIM in the transmission path degrades quality of the wireless communication system.

PIM is becoming a critical parameter recently due to installation of new technologies in communication industries such as higher RF transmission power, multi-band operation with a shared common antenna, or wider bandwidth signals with higher probability of PIM in the receiver band.

The Repeater:

Branch 63 installed ICOM VHF RP-2000 and UHF RP-4000 repeaters combined with the RP-2C internet connected controller. This controller allows the repeaters to be connected on demand to the D-Star world wide network of repeater and reflectors.

The remote WiFi connection to the internet server is detailed in an article here:

http://www.z12vh.org.nz/pdf/other/Mt_Climie_WiFi_Link_D-Star_Gateway_Link.pdf

Repeater equipment does not need to be ICOM. Many non ICOM repeaters around the world are in use. At the time of writing 60 % of repeater equipment is made by ICOM and 40 % non ICOM. These non ICOM repeaters are Motorola, GE, Tait, Tetra, Simoco and other commercial transceivers back to back having the flat response true FM talk through mode capability.

Here is two examples of non ICOM repeaters:

<http://www.wb0vhb.com/Dstar.html>

<http://vk5rex.squarespace.com/about-vk5rex/>

If your club is installing a new frequency i.e. not replacing an existing repeater on UHF then it is highly recommended to use the low end of the band for TX and the high end for RX.

This differs from what has been traditionally used in ZL before SRD's were introduced.

Known as the 'inverted repeater'

If using an ICOM repeater special attention to good filtering is essential at crowded RF sites.

The ICOM RP-2000 and RP-4000 suffer from in band desense.

For example at Mt. Climie the 147.3 MHz repeater overloaded the 145.425 MHz D-Star repeater.

Both repeaters used a satisfactory duplexer and identical antenna separated 40 meters from each other.

An additional high Q cavity filter was required on the input and output of the RP-2000 repeater.

The previous Tait T800 analogue repeater did not suffer from any overload.

Some D-Star operators have replaced the ICOM repeaters with Motorola equivalents and added the necessary internet interface.

The ICOM UHF RP-4000 repeater Branch 63 installed required an internal coax cable replacement.

Current consumption is high in RX at 500mA for each repeater and 500mA for the RP-2C controller.

Low power switching modification was required to operate on batteries during power outages.

See this site for details: http://www.z12vh.org.nz/pdf/other/RP4000_Power_Control.pdf

Summary:

- 1) Choose RF equipment carefully at crowded RF sites.
- 2) Choose inverted repeaters only on UHF.
- 3) Replacing a UHF analogue repeater that uses CTCSS to block SRD's is not an option. DV performance will be poor and the repeater will be unpopular.
- 4) Duplexer, coax cable and antenna must be in new condition. PIM rated.
- 5) VHF has less path loss than UHF giving better distance performance.
- 6) Install as NEW. D-Star should use equipment equivalent to the best club Analogue FM repeater. Make sure your D-Star repeater installation is not like "the poor relative" and remember Rubbish signal in = rubbish signal out with any repeater system.
- 7) Do not cover up a bad installation relying upon the error correction characteristics for D-Star to effectively mask a problem.

Check these URL's for more information:

<http://www.zl2vh.org.nz/dstar.php>

<http://www.dvrptr.net>

http://www.dvdongle.com/DV_Dongle/Home.html

73 and good DV

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